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A photograph of a rectangular, tan-colored ceramic armor tile with a recessed central area, positioned in the upper left corner of the slide.

Various Ceramics in Multilayer Composite Ground Vehicle Armor

Prepared for
ASM Int, **MS&T'07**, Cobo Center
by

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17 September 2007

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Planned Program

Silicon Nitride into pilot production

Why?

- Program basis: Silicon nitride was identified as a possible material solution (E_m , mass efficiency) for pellets in a pellet armor approach

- Program aim:
Cost reduction –
From \$200/Kg down to \$20/Kg.



2 of 12



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Ceramic Plate versus Ceramic Insert (or pellet)

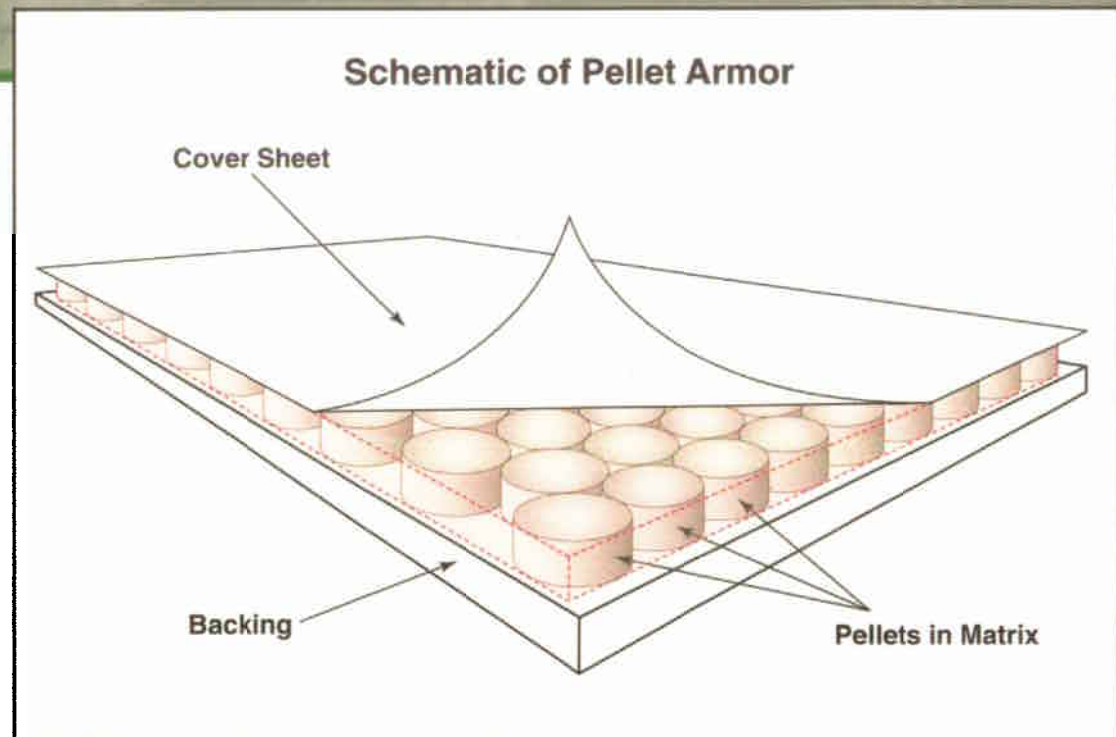
- As described in available filed patents, the claims are that an armor constructed of assembled ceramic pellets suspended in a matrix binder, performs better at defeating the same weight of armor made from a monolithic tile of the same ceramic.
- The force dynamics are significantly different for the interaction of pellets versus isolated tiles.
 - the ability for multi-hit is greater for pellet based armor

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Ceramic Pellet Armor

- Use:
Projectile/fragment ballistic defeat
- Typical Construction:
Cover sheet over pellets
in a matrix on an energy
absorbing backing



What is sought?

- Cooperative opportunities
- Applications: Personal armor,
Satellites, Light attack vessels,
Critical shipboard areas,
A current application - EFV



5 of 12



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Major Considerations For Ceramic Armor:

- Plate versus Insert
- Shape
- Size
- Material
- Material blending/mixing
- Composite inter-lay
- Backing support structure

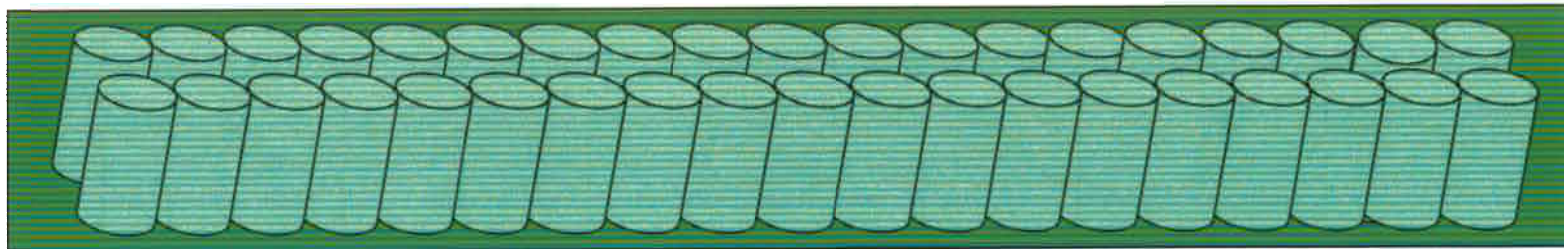
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Ceramic mini-tiles or
PELLETS or other shape



Medium melt temperature (take care)
Composite matrix



Pellets Tile Composite matrix – **the heart of Ceramic Insert Armor Systems (CIAS)**

7 of 12



Unclassified Considerations

- Different types of ceramics have different costs. Ceramics made by different processes and have distinctly different strengths and weaknesses.
- Common ceramic materials – Alumina – Aluminum Nitride – Boron Carbide – Boron Nitride – Glass (E & S) – Silicon Carbide – Silicon Nitride – Titanium Carbide – Tungsten Carbide

Why this configuration? - using E_m for comparing armor solutions:

- Monolithic Al_2O_3
- Monolithic SiC
- Ceramic insert composite matrix Al_2O_3
- Ceramic insert composite matrix SiC
- Ceramic insert composite matrix Si_3N_4



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Major Ceramic Insert Manufacturers



- BAE Systems (Cercom Inc.)
 - Cercom Incorporated of Vista, CA has been a prime producer of a wide range of commercial and ballistic grades of ceramics since 1985.
 - Using their pressure-assisted densification (PAD) process, Cercom has hot-pressed large quantities of aluminum nitride, boron carbide, silicon carbide, silicon nitride, titanium diboride and tungsten carbide ballistic ceramics for the U.S. Army.



- Ceradyne
 - Located Costa Mesa, California.
 - Fully integrated developer and manufacturer of advanced technical ceramic products and components for defense, industrial, automotive/diesel, electronic and medical markets.



- CoorsTek
 - Headquartered in Golden, Colorado
 - Serving virtually EVERY industry with advanced ceramics products and services...



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Major Ceramic Armor Assemblers/Finishers:

- GDLS (Mofet Etzion)
- Armor Holdings (BAE Systems)
- Plasan Sasa



- DefBar – new on the block

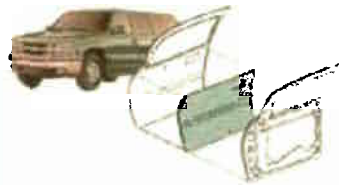


See their briefing this afternoon



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Potential Applications for very light armors:





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